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Dynamic Blocking of 5G Cells in Non-Standalone Networks

Todd Ou

Qin Zhang

Xiantao Sun

DYNAMIC BLOCKING OF 5G CELLS IN NON-STANDALONE NETWORKS

Abstract

A multi-mode user equipment (UE) employing multiple radio access technologies (RATs) detects secondary cell group (SCG) failures in a cellular network. The UE implements a dynamic blocking mechanism to block the new radio (NR) cell associated with the SCG failure from being subsequently added as a secondary cell during a blocking period/cycle. In one example, the UE adds the NR cell to a block list and sets a blocking period for the NR cell. During the blocking period, the UE does not send a cell measurement report to the cellular network for the NR cell, which prevents/blocks the network from adding the NR cell as a secondary cell. The blocking period is associated with a minimum blocking duration and a maximum blocking duration. The blocking duration for the NR cell can be dynamically adjusted for the blocking period. For example, the UE dynamically increases the blocking duration for the NR cell for each instance of SCG failure detected by the UE during the blocking period. The UE unblocks the NR cell after the blocking period has expired, which configures the UE to send a cell measurement report for the NR cell upon receiving a request from the cellular network. The dynamic blocking mechanism implemented by the UE prevents the frequent addition and removal of an NR cell associated with an SCG failure, which enhances the overall user experience when accessing the cellular network.

Background

Many cellular networks implement multiple RAT connectivity, allowing cellular phones and other UEs to concurrently connect to different radio access networks (RANs) or to connect to a single RAN employing multiple RATs. For example, a multi-mode UE can concurrently connect to a first base station employing a first RAT and to a second base station employing a second RAT to simultaneously transmit or receive data utilizing different RATs. One example of a cellular network configuration for implementing multiple RAT connectivity is Evolved Universal Terrestrial Radio Access (EUTRA)-New Radio (NR) Dual Connectivity (EN-DC), also known as Non-Standalone (NSA). A cellular network implementing an NSA configuration typically includes cells implementing a first RAT based on, for example, the Fourth Generation (4G) Long-Term Evolution (LTE) standard, and cells implementing a second RAT based on, for example, a Fifth Generation (5G) New Radio (NR) standard. In this configuration, a UE connects to a first base station, such as a 4G Evolved Node B (eNB), acting as a Master Node, and a second base station, such as a 5G NodeB, acting as a Secondary Node. The cell comprising the eNB operating as the Master Node can be referred to as the Master Cell Group (MCG). The cell comprising the 5G NodeB operating as the Secondary Node can be referred to as the Secondary Cell Group (SCG).

The cellular network typically configures NR SCG addition based on NR cell measurement reports provided by the UE. However, due to signal coverage or other reasons, SCG failure may occur after the cellular network has added an NR cell. In many instances, the cellular network may attempt to add an NR cell as a secondary cell even though the NR cell is associated with an SCG failure. This situation can create a looping state where the NR cell is continuously added with subsequent SCG failure, thereby resulting in a negative user experience, unnecessary battery consumption, and so on. Conventional mechanisms for addressing SCG failure usually result in a negative user experience since they block the addition of an NR cell for a constant amount of time or allow the addition or removal of the NR cell.

Description

Frequent addition of an NR cell associated with an SCG failure typically results in a negative user experience because the UE may continually attempt to connect to the NR cell without success. As described below, this situation can be mitigated by implementing a dynamic blocking mechanism at the UE. The dynamic blocking mechanism prevents an NR cell associated with an SCG failure from being added as a secondary cell by the cellular network during a blocking period. One example of a method for dynamic blocking of NR cell addition is shown below in Figure 1.

A UE registers with a cellular network providing multiple RAT connectivity, such as a cellular network implementing a 5G NSA architecture. As part of the registration process, the cellular network configures the UE with NR cell blocking configuration data (also referred to as "configuration data"). Examples of configuration data include a threshold number of SCG failures, monitoring duration, minimum NR cell blocking duration/time, maximum NR cell blocking duration/time, and so on. In one example, the cellular network configures the UE with configuration data for each different frequency range (FR) utilized by the cellular network. For example, the UE can be configured with a first set of configuration data for FR1 and a set of configuration data for FR2. If one of the frequency ranges, such as FR2, has a higher probability of SCG failure, the different sets of configuration data can be differentiated from each other. The different sets of configuration data allow for triggering the blocking mechanism for the different frequency ranges of the cellular network.

The UE receives a message from the cellular network providing details of an NR cell added by the network. The added NR cell details can be provided to the UE via a Radio Resource Control (RRC) Connection Reconfiguration message. In one example, the network adds the NR cell without configuring the UE for NR cell measurement (e.g., B1 Measurement). However, in another example, the network first configures the UE for NR cell measurement and then adds the NR cell based on the cell measurement data received from the UE. The UE monitors for an SCG failure associated with the added NR cell. In one example, the UE monitors SCG failures for a duration of time defined by, for example, the configuration data provided by the cellular network. The UE determines that an SCG failure has occurred based on, for example, a T313-expiry, a randomAccessProblem, a Radio Link Control (RLC) retransmission having reached a maximum threshold (rlc-MaxNumRetx), and so on.

Upon detecting an SCG failure for the NR cell, the UE determines if a threshold number of SCG failures for the NR cell has occurred. In one example, the threshold number of SCG failures is determined by the UE from the configuration data provided by the cellular network. If the threshold number of SCG failures has not occurred, the UE continues to monitor the NR cell for SCG failures. In one example, the configuration data provided by the cellular network may include a monitoring duration. In this example, if the UE determines that the threshold number of SCG failures for the NR cell has not occurred, the UE may further determine if a timer for the monitoring duration has expired. If the monitoring duration timer has expired, the UE resets the SCG failure count and monitoring duration timer. If the monitoring duration timer has not expired, the UE increases the SCG failure count and continues to monitor for SCG failures of the NR cell for the current monitoring duration.

If the threshold number of SCG failures has occurred, the UE blocks the NR cell's addition as a secondary cell. As part of the blocking process, the UE designates the NR cell associated with the SCG failures as a "blocked NR cell" and creates a record/entry for the NR cell in a list of blocked NR cells, which can be maintained locally on and/or remotely from the UE. The record created for the NR cell can include a flag that indicates whether the record is active or not, the NR Absolute Radio Frequency Channel Number (NR-ARFCN) of the NR cell, the NR Physical Cell Identifier (NR -PCI) of the NR cell, a timestamp of when the NR cell was blocked (or unblocked), the blocking duration set for the NR cell, which is dynamically adjustable, the measured signal strength of the NR cell when blocked, and so on. In one example, the UE stores the list of blocked NR cells in local memory or other storage such that the list is configured to be cleared or reset upon a power cycle of the UE. Configuring the list to be cleared upon a power cycle of the UE ensures that NR cells do not become unnecessarily blocked due to a software bug or glitch occurring at the UE.

When the NR cell is blocked, the UE does not transmit a measurement report, such as a B1 Measurement, for the NR cell during the blocking period so that the cellular network does not add the NR cell as a secondary cell. By not transmitting the measurement report, the UE prevents the frequent addition and removal of the NR cell by the cellular network due to SCG failures. In one example, the blocking period is configured with a minimum blocking duration and a maximum blocking duration. The NR cell is blocked for a duration of time, referred to as the blocking duration, during the blocking period. The blocking duration can be dynamically adjusted within the boundaries set by the minimum and maximum blocking durations. The UE can determine the minimum duration, maximum duration, and dynamic adjustment parameters from the configuration data provided by the cellular network.

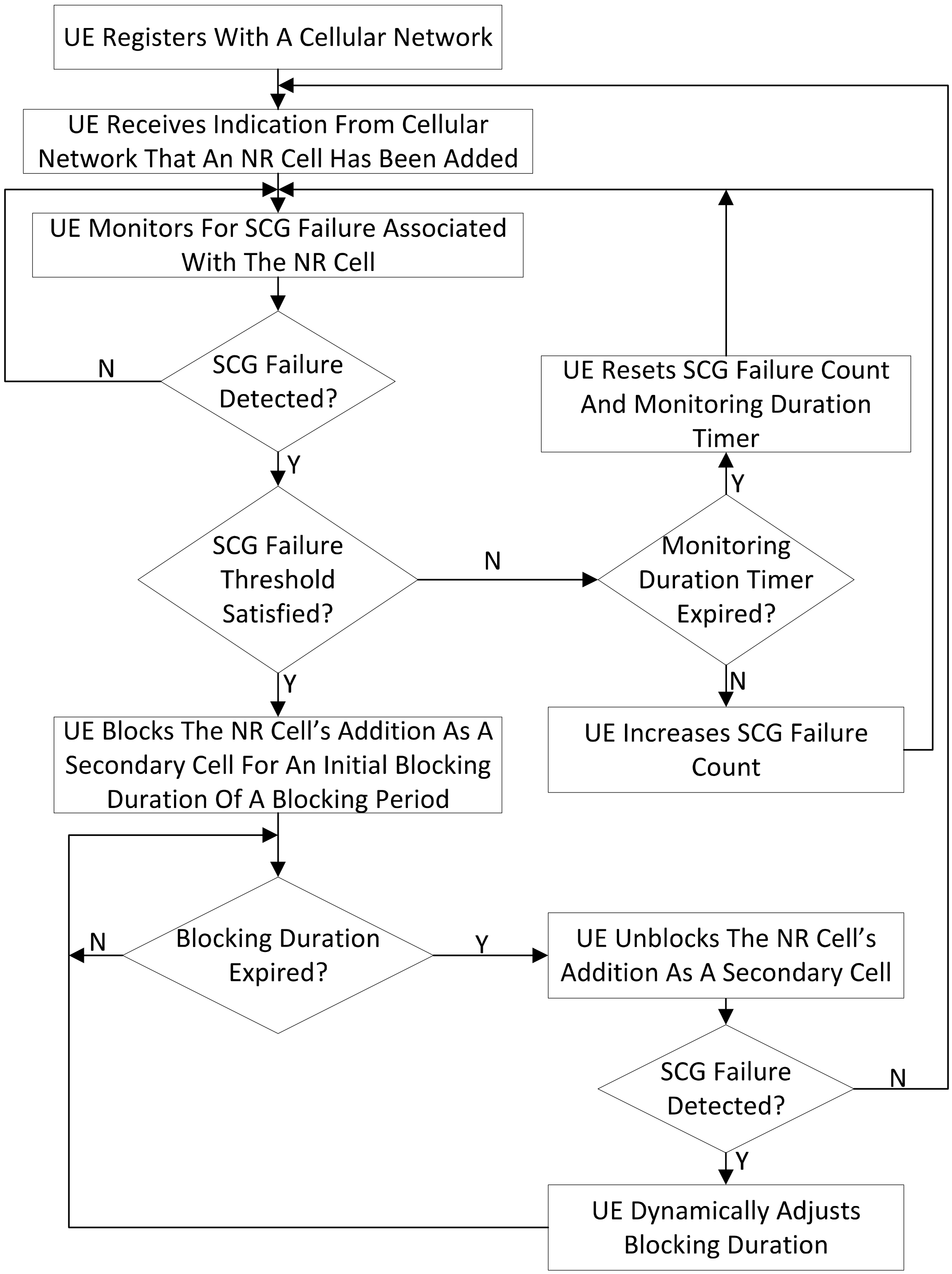
UE Registers With A Cellular Network
UE Receives Indication From Cellular Network That An NR Cell Has Been Added
UE Monitors For SCG Failure Associated With The NR Cell
SCG Failure Detected?
N
Y
SCG Failure Threshold Satisfied?
N
Y
Monitoring Duration Timer Expired?
Y
N
UE Resets SCG Failure Count And Monitoring Duration Timer
UE Increases SCG Failure Count
UE Blocks The NR Cell's Addition As A Secondary Cell For An Initial Blocking Duration Of A Blocking Period
Blocking Duration Expired?
N
Y
UE Unblocks The NR Cell's Addition As A Secondary Cell
SCG Failure Detected?
N
Y
UE Dynamically Adjusts Blocking Duration

Figure 1

Figure 2 below illustrates one example of a blocking pattern implemented by the UE. In this example, the UE blocks the NR cell's addition for at least a minimum time duration and not more than a maximum time duration when a threshold number of SCG failures has been reached. When the UE detects a given number (e.g., 1) of SCG failures for the blocked NR cell during the blocking period, the UE applies a multiplier to the current blocking duration of the NR cell. For example, in Figure 2, each diagonally-hatched block represents an SCG failure of the blocked NR cell. Each cross-hatched block represents a blocking duration of the NR cell within the blocking period. In this example, the initial blocking duration is represented by a single block. However, after the UE detects a second SCG failure for the NR cell within the blocking period, the UE dynamically adjusts the initial blocking duration by applying a multiplier of, for example, 2 to the initial blocking duration. Two consecutive cross-hatched blocks represent the dynamically adjusted blocking duration. After the UE detects a third SCG failure for the NR cell within the blocking period, the UE once again dynamically adjusts the current blocking duration by applying a multiplier of, for example, 2 to the current blocking duration. Four consecutive cross-hatched blocks represent the new dynamically adjusted blocking duration. The UE continues to dynamically adjust the blocking duration each time an SCG failure is detected for the NR cell during the blocking period until the maximum blocking duration is reached.

After the blocking period has expired, the UE unblocks the NR cell. The UE can also unblock the NR cell before the blocking period has expired. For example, if the NR cell was blocked with an indication of a low NR signal, but the signal strength subsequently increases to a threshold strength value, the UE can cancel the blocking period and unblock the NR cell. In one example, the UE updates the NR cell's record in the list of blocked NR cells to include a timestamp indicating the time at which the NR cell was unblocked. The NR cell's record can be removed from the list of blocked NR cells after the NR cell becomes unblocked, and an SCG failure does not occur for a period of time after the NR cell is re-added by the cellular network. After the NR cell is unblocked, the UE is configured to generate and transmit measurement reports (e.g., B1 Measurement) for the NR cell when requested by the cellular network as described in, for example, the Third Generation Partnership Project (3GPP) Release 15, 3GPP Release 16, etc. If an SCG failure is detected within a period of time after the NR cell is unblocked, the UE can dynamically adjust the blocking duration and block the NR cell for the adjusted duration.

In some instances, a primary NR cell (SpCell) may be currently established in the NSA mode, and the blocked (or blocking candidate) NR cell may be an NR cell that the cellular network attempts to add for handover. For example, when a neighboring NR cell becomes offset better than the primary NR cell (SpCell) of the SCG, the cellular network may add the neighboring NR cell through "nr-SecondaryCellGroupConfig-r15" in rrcConnectionReconfiguration and schedule an A3 Measurement in NR-RRC to trigger the NR cell handover. In this situation, the UE can prevent the handover to a blocked neighboring NR cell (or a neighboring NR cell that can potentially fail) by implementing the dynamic blocking techniques described above. The UE further notifies the NR RRC layer of the current list of blocked NR cells when the cellular network attempts to add the blocked neighboring NR cell or a neighboring NR cell for handover. The UE also suppresses the measurement report (e.g., A3 measurement report) with regard to the blocked or unblocked neighbor NR cells. For example, even if the blocked neighbor NR cell is subsequently unblocked due to the expiration of the blocking period (or timer), signal strength threshold being satisfied, and so on, the UE still blocks the A3 Measurement since it has one active NR cell connection and, therefore, does not need to handover to a new NR cell that has failed or could potentially fail.

Use of the approaches outlined above, individually or in combination, provides an improved user experience because the NR cells associated with SCG failures are blocked from being continually added and removed by the cellular network. This prevents service interruptions experienced by the UE due to the SCG failures, unnecessary battery consumption, and so on.

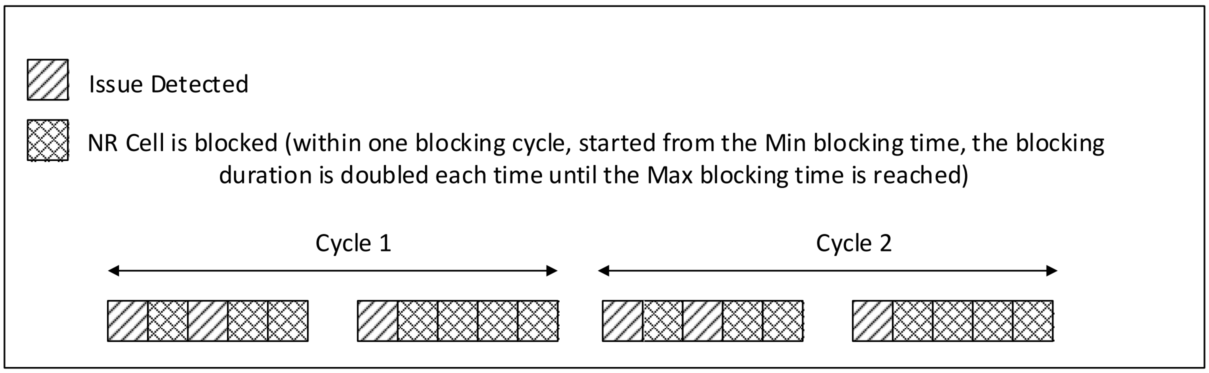

Figure 2

References

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